User's Manual

PQ Series

Programmable DC Power Supply

AMERICAN RELIANCE INC.

Operation Manual

PQ Series

Programmable DC Power Supply

Revision 1.0
Date: 04-11-02

/ AMERICAN RELIANCE INC.
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LIMITED WARRANTY

American Reliance warrants to the original user or purchaser that your unit is free from any defects in material or workmanship for a period of one year from the date of purchase. If any defect is discovered within the warranty period, American Reliance will repair or replace the unit, subject to verification of the defect or malfunction, upon delivery or prepaid shipment to American Reliance.

IMPORTANT:

(1) Unless a problem is discovered upon initial inspection after purchase of the unit, please do not return the product to the distributor where it was purchased. American Reliance accepts the responsibility of keeping you a satisfied customer.
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This warranty does not apply to defects or to physical damage resulting from abuse, neglect, accident, improper repair, alteration, or unreasonable use of the unit, resulting in (but not limited to) cracked or broken cases or parts, or to units damaged by excessive heat. Except upon initial purchase, this warranty does not cover finish or appearance items nor does it cover items damaged in shipment to American Reliance for repair or calibration.

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This warranty is in lieu of all other agreements and warranties, general or specific, express or implied. No representative or person is authorized to assume for us any other liability in connection with the sale or use of this American Reliance product.

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The instrument should be returned to American Reliance, please follow the directions under the heading "Shipping Instructions" in this section.

SHIPPING INSTRUCTIONS

Any product returned to American Reliance for service must be shipped, freight prepaid (we will not accept COD shipments).

American Reliance Inc.
5440 Peck Rd.,
El Monte, CA 91732
Attn: RMA # _____

Please obtain return authorization from AMREL before returning any product.

The instrument must be carefully packed, preferably in its original carton with PE Foam, and should be accompanied by a letter or note containing the following information:

User's Name	Proof of Purchase
User's Address	Description of problem
Model number	Serial number

If service is desired, such as calibration, it must be stated in the enclosed letter. For non-warranty repairs, and for calibration, the correct service charge must accompany the unit in the form of a check or money order payable to American Reliance Inc. Please do not send cash. Contact our service department at (877) 267-4805.

American Reliance will return the serviced instrument, with freight paid by American Reliance, via UPS ground service unless otherwise requested.

NOTE: ALL INSTRUMENTS THAT ARE RETURNED FOR REPAIR OR CALIBRATION MUST HAVE AN ASSIGNED R.M.A. NUMBER WRITTEN ON THE FRONT OF THE PACKAGE. THIS NUMBER MAY BE OBTAINED BY OUR SERVICE DEPARTMENT. ANY INSTRUMENT DELIVERED WITHOUT THIS NUMBER WILL BE REFUSED, AND RETURNED.

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1.0 GENERAL INFORMATION

1.1 Description

This manual contains operation and maintenance instructions for American Reliance's PQ Series, medium frequency link power supplies. These power supplies are constant voltage/constant current sources suitable for a wide range of applications.

1.2 Features

American Reliance's PQ SERIES power supplies set a new standard for high-powered dc supplies. A combination of high and medium frequency power processing technologies improves response, shrinks package size, and reduces cost. PQ SERIES power supplies are current fed. Compared with conventional switching power supplies, these supplies can easily tolerate the punishment of the most rigorous applications.

PQ SERIES power supplies are fully programmable via resistance, voltage, current, or optional IEEE-488/RS232. While other supplies can remotely control only output voltage and current, PQ SERIES units also allow programming of over voltage and over current protection. Program lines are constantly monitored for range of operation. If a line should open or if a programmable input is set beyond that anticipated, the unit safely shuts down protecting the load.

PQ SERIES power supplies can operate as a voltage source or current source depending on the control settings and load conditions. If the power supply is operating as a voltage source and the load increases to a point beyond the current command setting, the power supply automatically crosses over to current mode control and operates as a current source at that setting.

Differential amplifiers isolate the programming lines from the dc output allowing programming at any distance from the load. Additional differential amplifiers are provided for master/slave series or parallel operation.

Diagnostic functions are contained directly within the supply's control loop. Exclusive circuitry eliminates guesswork about which function has control -- voltage, current, or a fault condition. If the fault condition requires user attention, main power is disconnected and the diagnostic condition is latched into memory. Pressing the reset switch clears the memory. All diagnostic functions are monitored with optical isolators that can be paralleled for master/slave operation. Furthermore, control functions can also be set through optical isolators to allow simultaneous control of one or more PQ SERIES units. Programming switches in the rear of the supply enable internal operation of controls, external operation, or both.

PQ SERIES supplies have three levels of over voltage/current protection: shutdown of controlling insulated gate bipolar transistors (IGBT's), disconnect of main power, and optional SCR crowbar. After an over voltage/current condition, the supply must be reset. Pressing the reset switch causes the over voltage/current settings to be displayed on the front meters.

PQ SERIES power supplies have push button start/stop controls. These controls are electrically integrated to a mechanical contactor which operates with the electronic switches to break the ac mains when stop is commanded. Unlike competing products, an off means both an electrical and mechanical break in the power circuit — not a break in an electronic switch. Safety comes first at American Reliance.

1.3 Cooling

Each power supply enclosure is cooled by suitable blowers exhausting warm air to the rear of the cabinet. Fresh air intake is from the sides of the cabinet allowing two or more PQ Series supplies to be stacked. Blocking ventilation will cause the power supply to overheat.

1.4 Installation

The power supply is capable of being rack or bench mounted. For rack mount installations, additional support, other than that provided by the front panel, is required. Angle slides or cross beam supports securely fastened to the rack are recommended for supporting the weight of the power supply. The unit should be horizontally mounted.

1.5 Power Requirements

A suitable source of ac power is required for this supply. The unit is wired for 208 V, 3• ;50 to 60 Hz mains. For 240 V operation, two internal wiring changes must be made to the unit. Information concerning conversion is covered in Section 2.14.

PQ Series power supplies are optionally available for operation on 440/480 V, 3• ;50 to 60 Hz mains. Units are normally wired for 480 V operation and information concerning conversion is covered in Section 2.14.

1.6 Specifications

The following specifications describe the published operational characteristics of the PQ series power supplies.

Input voltage: 208/240 Vac, 50-60 Hz, 3• standard; 440/480 Vac, 50-60 Hz, 3• optional.

Regulation line and load combined: 0.10 %.

Stability: 0.10 % for 8 hours after 30 minute warm up.

Transient response: 40.0 ms to recover within 2 % of regulated output with a 30 % step load change.

Programming resistors: 1 K• •full scale for output voltage, output current, over voltage shutdown, and over current shutdown.

Ambient Temperature: 0 to 50°C.

Storage Temperature: -25 to +85°C.

Temperature coefficient: 0.04 %/°C of maximum output current.

Size: 5¼"H x 19"W x 24"D, see figure 1.1 for details.

Weight: 125 lbs for 10 kW models, 97 lbs for 6.6 kW models, and 74 lbs for 3.3 kW models.

10 KW MODELS AND RATINGS

MODEL	VOLTS Vdc	AMPS Adc	RIPPLE mVrms	EFF. %	INPUT CURRENT (Aac)	
					208/240 V MODELS	440/480 V MODELS
PQ16-600	16	600	40	86	36	18
PQ20-500	20	500	35	86	36	18
PQ32-300	32	300	30	86	36	18
PQ40-250	40	250	35	87	36	18
PQ50-200	50	200	40	87	36	18
PQ80-125	80	125	50	87	36	18
PQ100-100	100	100	55	87	35	17
PQ125-80	125	80	60	87	35	17
PQ160-62	160	62	70	87	35	17
PQ200-50	200	50	80	87	35	17
PQ250-40	250	40	90	88	35	17
PQ375-27	375	27	100	88	35	17
PQ500-20	500	20	130	88	35	17
PQ625-16	625	16	150	88	35	17

6.6 KW MODELS AND RATINGS

MODEL	VOLTS Vdc	AMPS Adc	RIPPLE mVrms	EFF. %	INPUT CURRENT (Aac)	
					208/240 V MODELS	440/480 V MODELS
PQ10-600	10	600	40	86	24	12
PQ16-400	16	400	40	86	24	12
PQ20-330	20	330	35	86	24	12
PQ32-200	32	200	30	86	24	12
PQ40-165	40	165	35	87	24	12
PQ50-130	50	130	40	87	24	12
PQ80-82	80	82	50	87	24	12
PQ100-66	100	66	55	87	23	12
PQ125-53	125	53	60	87	23	12
PQ160-41	160	41	70	87	23	12
PQ200-33	200	33	80	87	23	12
PQ250-26	250	26	90	88	23	12
PQ375-17	375	17	100	88	23	12
PQ500-13	500	13	130	88	23	12
PQ625-10	625	10	150	88	23	12

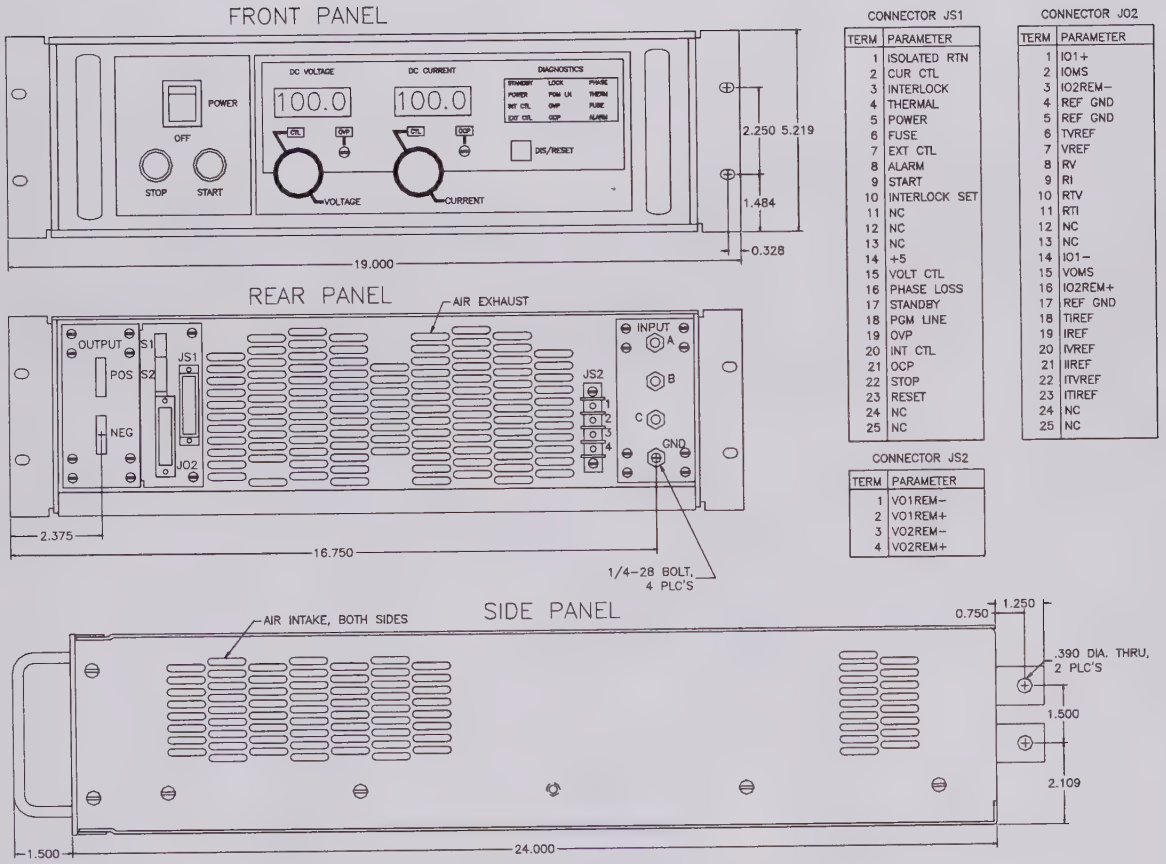
3.3 KW MODELS AND RATINGS

MODEL	VOLTS Vdc	AMPS Adc	RIPPLE mVrms	EFF. %	INPUT CURRENT (Aac)	
					208/240 V MODELS	440/480 V MODELS
PQ10-300	10	300	40	86	12	6
PQ16-200	16	200	40	86	12	6
PQ20-165	20	165	35	86	12	6
PQ32-100	32	100	30	86	12	6
PQ40-82	40	82	35	87	12	6
PQ50-65	50	65	40	87	12	6
PQ80-41	80	41	50	87	12	6
PQ100-33	100	33	55	87	12	6
PQ125-26	125	26	60	87	12	6
PQ160-20	160	20	70	87	12	6
PQ200-16	200	16	80	87	12	6
PQ250-13	250	13	90	88	12	6
PQ375-8	375	8	100	88	12	6
PQ500-6	500	6	130	88	12	6
PQ625-5	625	5	150	88	12	6

Notes:

1) Rating specified at 208 and 440 V input.

2) Specifications subject to change without notice.



CONNECTOR JS1

TERM	PARAMETER
1	ISOLATED RTN
2	CUR CTL
3	INTERLOCK
4	THERMAL
5	POWER
6	FUSE
7	EXT CTL
8	ALARM
9	START
10	INTERLOCK SET
11	NC
12	NC
13	NC
14	+5
15	VOLT CTL
16	PHASE LOSS
17	STANDBY
18	PGM LINE
19	OVP
20	INT CTL
21	OCP
22	STOP
23	RESET
24	NC
25	NC

CONNECTOR JO2

TERM	PARAMETER
1	IO1+
2	IOMS
3	IO2REM−
4	REF GND
5	REF GND
6	TVREF
7	VREF
8	RV
9	RI
10	RTV
11	RTI
12	NC
13	NC
14	IO1−
15	VOMS
16	IO2REM+
17	REF GND
18	TIREF
19	IREF
20	IVREF
21	IIREF
22	ITVREF
23	ITIREF
24	NC
25	NC

CONNECTOR JS2

TERM	PARAMETER
1	VO1REM−
2	VO1REM+
3	VO2REM−
4	VO2REM+

Figure 1.1 PQ Series package drawing

2.0 OPERATING INSTRUCTIONS

2.1 General Operation

As shipped, the power supply is configured for local sensing, internal programming, and 208 V, 3• • input. The front panel voltage and current controls set the boundary limits for output voltage and current, respectively. The impedance of the load determines whether the unit is voltage or current controlled and the illumination of the respective mode indicator light indicates the state. If either control is set to maximum counter clockwise rotation, the other control will have little or no effect. Each control must be set to the appropriate position for proper operation.

2.2 Controls and Indicators

The controls and indicators are illustrated in figure 2.1.

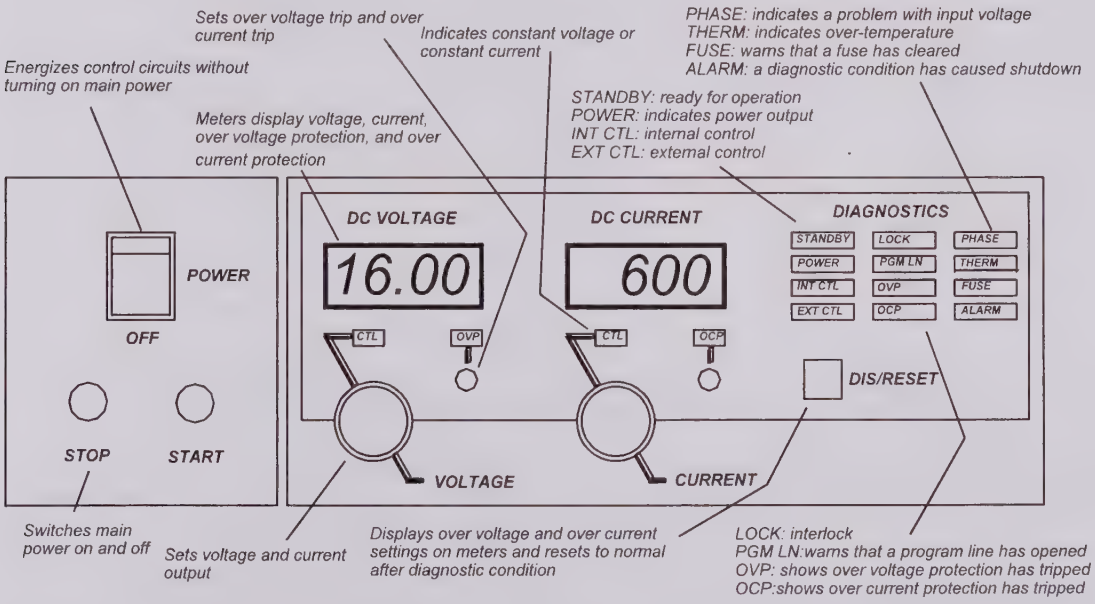


Figure 2.1 Controls and indicators

2.3 Preparation for Use

2.3.1 Unpacking

Carefully unpack the power supply saving all packing materials and included enclosures. Inspect power supply for possible shipping damage. Check that there are no broken knobs or connectors, the external surface is not scratched or dented, the meter faces are not damaged, and all controls move freely. Any external damage may be an indication of internal damage.

2.3.2 Electrical Check

Check that switches S1 and S2, located at the rear of the supply, are set to position 1, the default switch positions. As shown in figure 2.2, switch positions depict normal local sense and programming configurations. It is recommended that the following brief electrical check be made shortly after unpacking the supply.

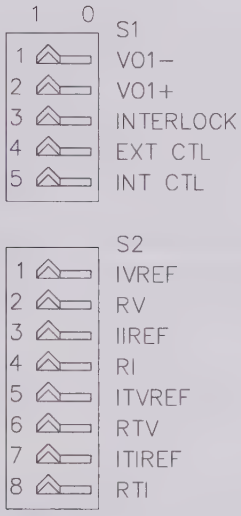


Figure 2.2 Default switch positions for S1 and S2 (on is state 1 and off is state 0)

Set voltage and current controls full counterclockwise, turn the power switch off and connect a short circuit to the power output studs on the rear panel. Connect the power supply to a suitable source of ac voltage. For this test, only 50% of rated ac current is required.

Turn the power switch on. The standby, internal control (int ctl), and external control (ext ctl) lights should come on. Press the start switch and advance the voltage control one turn clockwise. The standby light should extinguish and the power and current control lights should come on. Press the display/reset switch and adjust the over current trip to maximum current by means of the screw driver adjustment potentiometer. Increase the current setting to maximum and then to minimum. DC current should increase smoothly from minimum to maximum to minimum as indicated on the meter. Return the current control full counterclockwise.

Press the display/reset switch and adjust the over current trip to half-rated current. Slowly increase the current setting. Over current trip should operate at the over current trip setting, the over current light should come on, and the supply should shut down. Press the display/reset switch and adjust the

over current trip to maximum current. Adjust the current control full counterclockwise and restart the supply. The supply should operate normally

With the power supply off, disconnect the output short circuit. Turn the power switch on. Press the start switch and advance the current control one turn clockwise. The standby light should extinguish and the power and voltage control lights should come on. Press the display/reset switch and adjust the over voltage trip to maximum voltage by means of the screw driver adjustment potentiometer. Increase the voltage setting to maximum and then to minimum. DC voltage should increase smoothly from minimum to maximum to minimum as indicated on the meter. Return the voltage control full counterclockwise.

Press the display/reset switch and adjust the over voltage trip to half-rated voltage. Slowly increase the voltage setting. Over voltage trip should operate at the over voltage trip setting, the over voltage light should come on, and the supply should shut down. Press the display/reset switch and adjust the over voltage trip to maximum voltage. Adjust the voltage control full counterclockwise and restart the supply. The supply should operate normally.

If any of these events do not occur, the supply is defective and should not be operated. Depending on the circumstances, either warranty service or trouble shooting as described in Section 4.2 is required.

2.4 Modes of Operation

2.4.1 Normal Mode

PQ series power supplies are normally shipped with its switch settings arranged for constant voltage/constant current, local sensing, and local programming. This is set by the programming switches, S1 and S2, located at the rear of the supply. As illustrated in figure 2.2, all of the programming switches should be set to position 1. The operator selects either a constant voltage or a constant current output using the front panel controls (local programming, no switch changes are necessary).

2.4.2 Constant Voltage

To select a constant voltage output, proceed as follows:

With the supply off, set all controls to full counterclockwise and advance current control one turn clockwise. Turn on the power supply and adjust the voltage trip to 110% of desired output voltage. Advance the voltage control for the desired output voltage with the output terminals open.

Turn the supply off and short the output terminals. Turn on the supply and adjust the current control for the maximum output current allowable as determined by load conditions. If a load change causes the current limit to be exceeded, the power supply will automatically crossover to

constant current output at the preset current limit and the output voltage will drop proportionately. In setting the current limit, allowance must be made for high peak currents which can cause unwanted crossover (see section 2.13).

Turn off the power supply, remove the short on the output terminals, and connect the load. The unit is now ready for operation.

2.4.3 Constant Current

To select a constant current output, proceed as follows:

With the supply off, short the output terminals, set all controls to full counterclockwise, and advance the voltage control one turn clockwise. Turn on the power supply and adjust the current trip to 110% of desired output current. Advance the current control for the desired output current with the output terminals shorted.

Turn off the supply and remove the short on the output terminals. Turn on the power supply and adjust the voltage control for maximum output voltage allowable as determined by load conditions. If a load change causes the voltage limit to be exceeded, the power supply will automatically crossover to constant voltage output at the preset voltage limit and the output current will drop proportionately.

Turn off the power supply and connect the load. The unit is now ready for operation.

2.5 Remote Sensing

Remote sensing is used to improve the degradation of regulation which will occur at the load when the voltage drop in the connecting wires is appreciable. This is done by setting switch positions 1 and 2 of S1 to 0. Using a pair of #20 AWG wires, connect terminal 2 of JS2 to the positive terminal of the load and connect terminal 1 of JS2 to the negative terminal of the load.

Figure 2.3 illustrates standard output sensing and remote output sensing.

2.6 Standard Programming

The standard programming configuration, illustrated in figure 2.4, shows that references for voltage, current, voltage trip, and current trip are established by internal 2 mA current sources producing voltages across potentiometers RV, RI, RTV, and RTI. These potentiometers are the front panel controls for voltage, current, voltage trip, and current trip, respectively.

Resistors placed in series with the voltage and current trip potentiometers allow settings above the maximum voltage and current of the power supply.

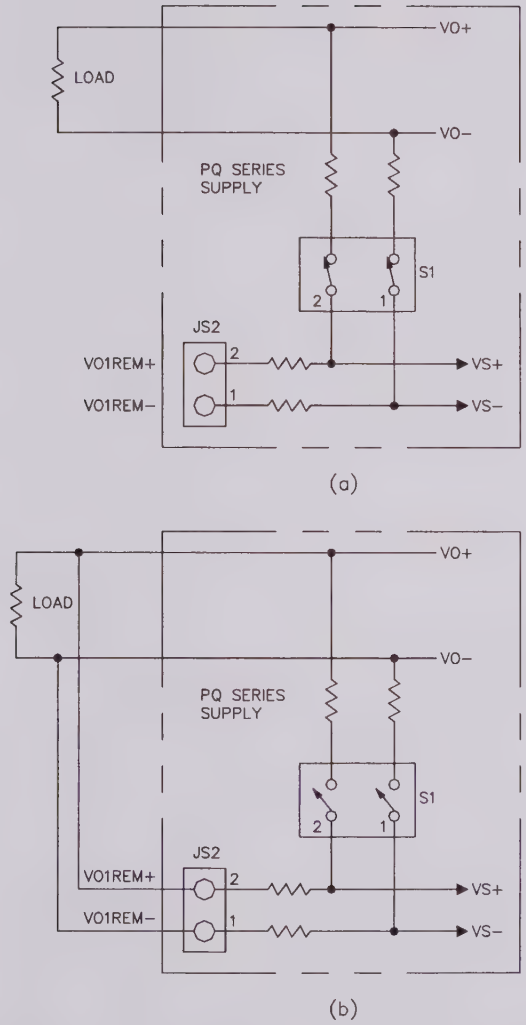


Figure 2.3 (a) Standard and (b) remote sensing

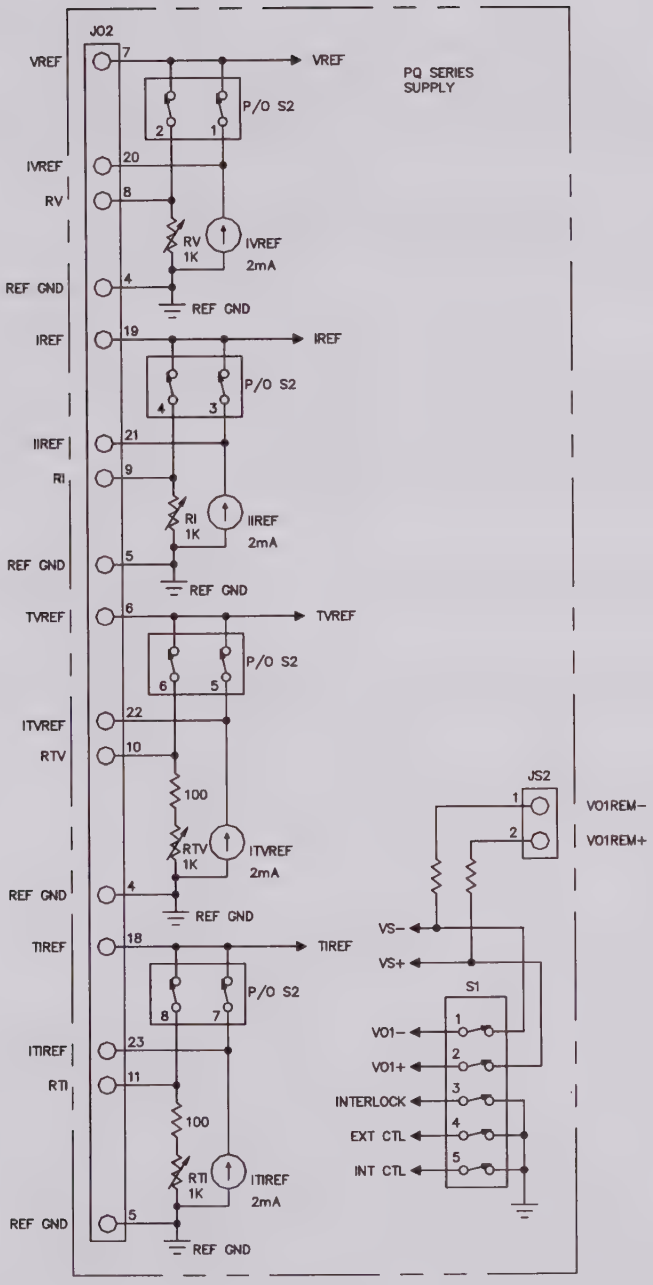


Figure 2.4 Standard programming configuration using internal potentiometers

2.7 Remote Programming

PQ series supplies allow voltage, current, voltage trip, and current trip to be programmed from a remote location. Programming can be accomplished either by resistive, voltage, or current programming circuits.

Figure 2.5 illustrates the three alternatives for programming output voltage. The method applies equally to programming an output current, voltage trip, and current trip.

2.7.1 Resistive Programming

Resistive programming requires setting position 2 of S2 to 0 and connection of an external potentiometer or resistor between terminals 20 and 4 of JO2. Like the internal voltage potentiometer, the 2 mA reference produces a voltage across the potentiometer or resistor which is used to set the output voltage. A metal film resistor or wire wound potentiometer will result in the lowest temperature coefficient.

To program an output current, voltage trip, or current trip, use the same method and refer to figure 2.4 for terminal identification.

The expressions for programming output voltage, V_O, output current, I_O, voltage trip, T_V, and current trip, T_I are given as follows.

$$V_O = \frac{V_{OMAX} R_P}{1000\Omega} \quad (1)$$

$$I_O = \frac{I_{OMAX} R_P}{1000\Omega} \quad (2)$$

$$T_V = \frac{V_{OMAX} R_P}{1000\Omega} \quad (3)$$

$$T_I = \frac{I_{OMAX} R_P}{1000\Omega} \quad (4)$$

where:

V_{OMAX}: maximum output voltage,
I_{OMAX} : maximum output current,
R_P: programming resistor.

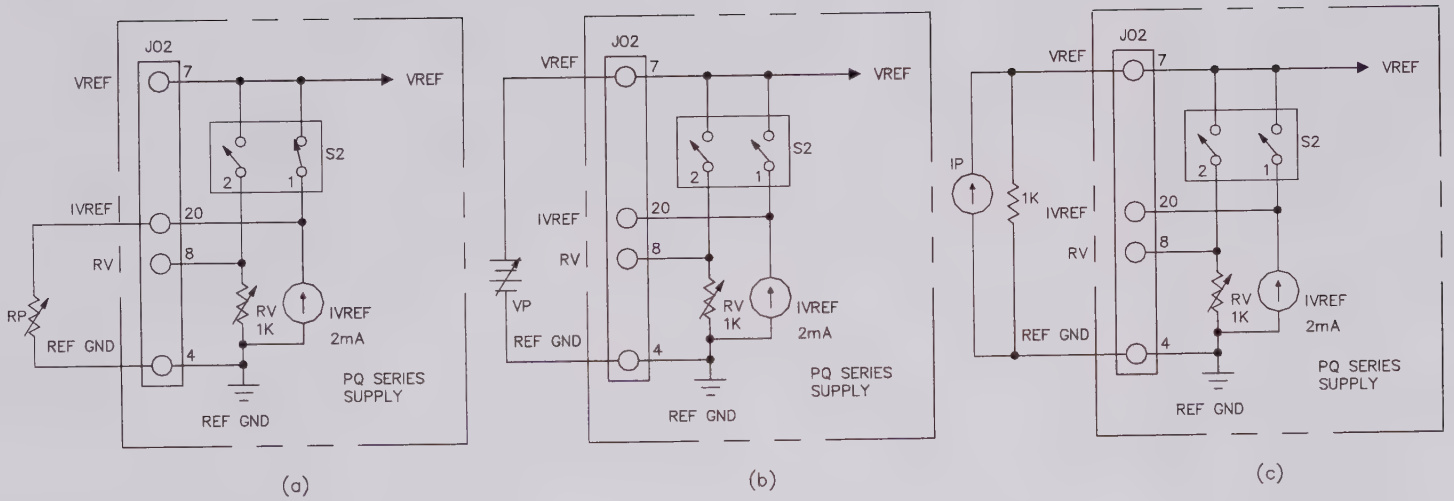


Figure 2.5 External (a) resistive, (b) voltage, and (c) current programming

2.7.2 Voltage Programming

Voltage programming requires setting positions 1 and 2 of S2 to 0 and connection of an external voltage reference between terminal 7 of JO2 (positive) and terminal 4 of JO2 (negative).

To program an output current, voltage trip, or current trip, use the same method and refer to figure 2.4 for terminal identification.

The expressions for programming output voltage, V_O, output current, I_O, voltage trip, T_V, and current trip, T_I, are given as follows.

$$V_O = \frac{V_{OMAX} V_P}{2.0V} \tag{5}$$

$$I_O = \frac{I_{OMAX} V_P}{2.0V} \tag{6}$$

$$T_V = \frac{V_{OMAX} V_P}{2.0V} \tag{7}$$

$$T_I = \frac{I_{OMAX} V_P}{2.0V} \tag{8}$$

where:

V_P: programming reference voltage.

2.7.3 Current Programming

Current programming requires setting positions 1 and 2 of S2 to 0, connection of an external, 1K metal film resistor between terminal 7 of JO2 and terminal 4 of JO2, and connection of an external current source between terminal 7 of JO2 (positive) and terminal 4 of JO2 (negative).

To program an output current, voltage trip, or current trip, use the same method and refer to figure 2.4 for terminal identification.

The expressions for programming output voltage, V_O, output current, I_O, voltage trip, T_V, and current trip, T_I, are given as follows.

$$V_O = \frac{V_{OMAX} I_P}{2.0mA} \tag{9}$$

$$I_O = \frac{I_{OMAX} I_P}{2.0mA} \tag{10}$$

$$T_V = \frac{V_{OMAX} I_P}{2.0mA} \tag{11}$$

$$T_I = \frac{I_{OMAX} I_P}{2.0mA} \tag{12}$$

where:

I_P: programming current source.

2.8 Voltage and Current Monitoring

Two operational amplifiers are provided for master/slave series and parallel operation. As illustrated in figure 2.6, these amplifiers can also be used to monitor output voltage and current. These outputs may be used for external instrumentation or process control.

To monitor the output voltage, connect terminal 4 of JS2 to the positive output of the supply and terminal 3 of JS2 to the negative output of the supply. The voltage between terminals 15 to 4 of JO2 represents the output voltage normalized to 2.0 V full scale.

To monitor the output current, connect terminal 16 of JO2 to terminal 1 of JO2 and connect terminal 3 of JO2 to terminal 14 of JO2. The voltage between terminals 2 to 4 of JO2 represents the output current normalized to 2.0 V full scale.

2.9 Digital Control Lines

All input and output control lines are connected to optical isolators for a wide range of applications.

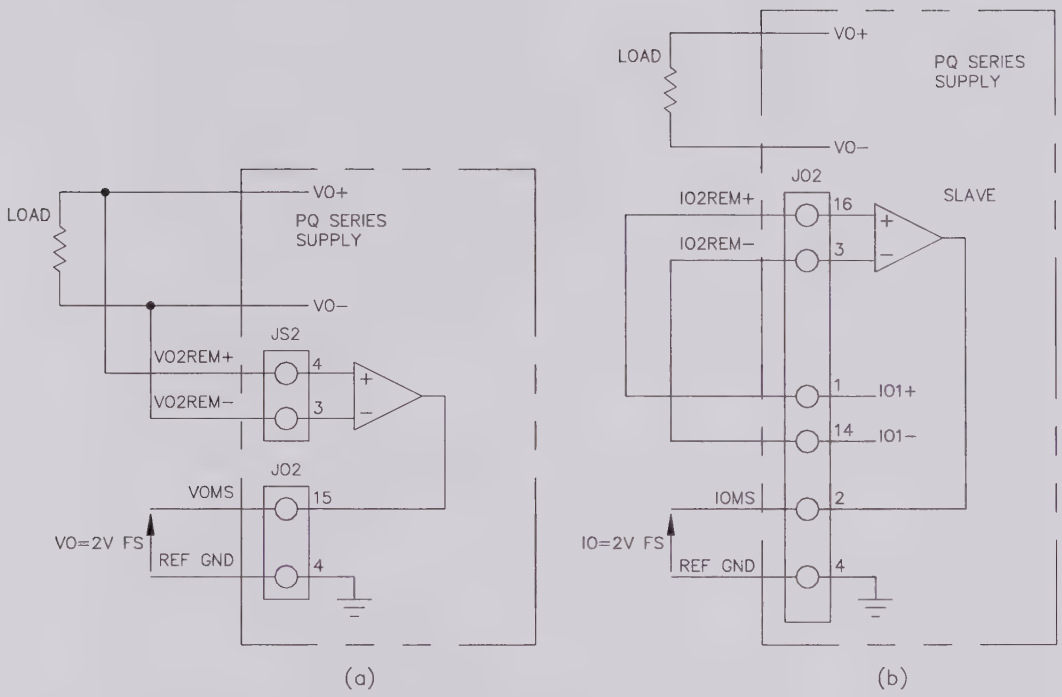


Figure 2.6 Monitoring output (a) voltage and (b) current

Input control lines are or'd with front panel controls for start, stop, interlock set, and reset. To force any state, apply +5 V between the input control line and isolated return. An isolated 5 V, 100 mA source is provided at terminal 14 of JS1 for this application. As illustrated in figure 2.7, digital control lines may be paralleled with other supplies to allow simultaneous control. The front panel controls can be disabled by setting position 5 of switch S1 to 0. Likewise, the external control lines can be disabled by setting position 4 of switch S1 to 0.

Output monitoring lines provide a means to monitor diagnostic functions as well as mode of operation (voltage or current). Figure 2.8 shows that diagnostic functions can be or'd with other supplies to simplify problem detection in large systems.

All digital lines, both control and monitoring, are referenced to a common isolated return.

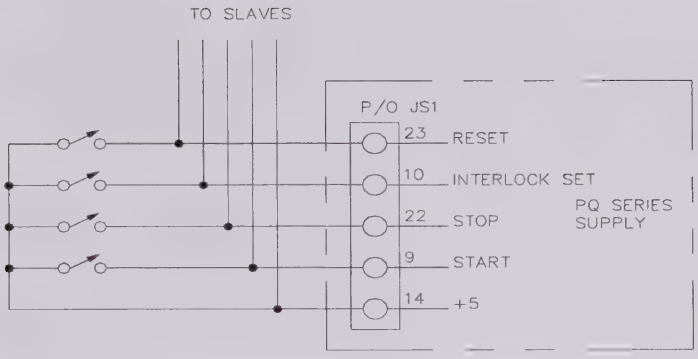


Figure 2.7 Digital control lines

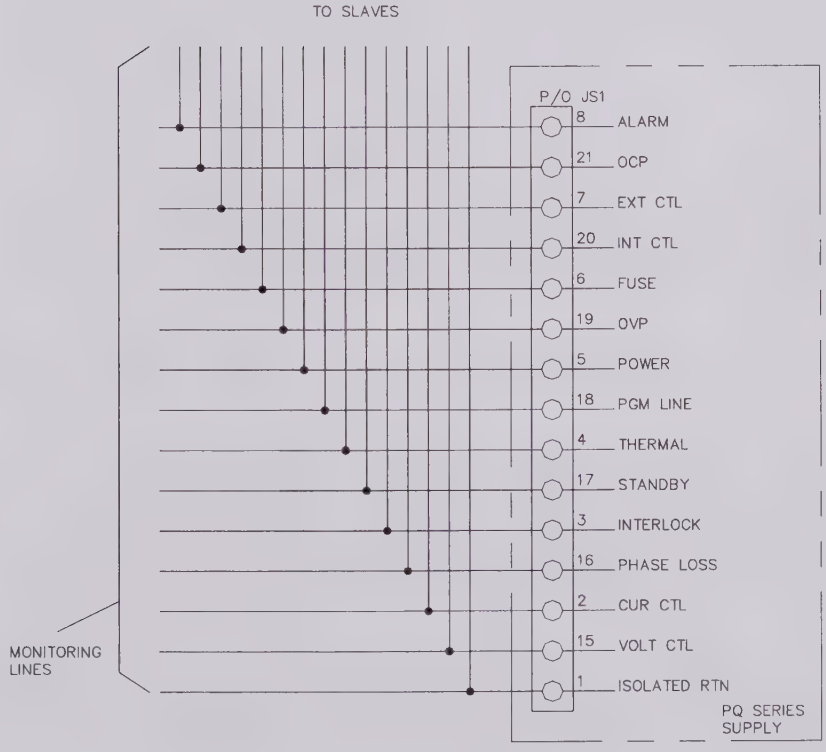


Figure 2.8 Digital output monitoring lines

2.10 Diagnostic Functions

Diagnostic functions and mode of control are embedded in the supply's closed loop control. The power supply will operate under voltage control or current control depending on which setting is lowest. Voltage control and current control also contain a soft start function which causes voltage and/or current to ramp to the desired set point after power is initiated. The soft start circuitry is reset upon power-on or operation of any diagnostic function.

Diagnostic functions include thermal overload, interlock, power, standby, phase loss, program line, fuse, over voltage, over current, and alarm. All diagnostic indicators have memory retention which saves the fault condition until the power supply is reset. To clear a fault condition, the user must press the display/reset switch on the front panel. Alternatively, the supply can be reset by turning the power supply off and on.

Thermal overload indicates that the input power processing devices or output rectifiers have reached a critical temperature. A resetting thermal breaker will reset upon cooling.

Standby indicates that the control circuits are powered, but the supply is disabled through the ac contactor. This is the power supply's normal off condition. To start the supply, press the start switch. To place the supply in standby, press the stop switch.

Phase loss indicates a problem with the power mains voltage.

Opening of a program line can cause the voltage, current, over voltage, or over current trip reference to be set beyond the range of control. These lines are constantly monitored and if any of these references are set above the normal bounds, program line diagnostics will disable the supply.

Fuse indicates that one of the three main fuses has cleared. Power must be removed from the supply and the fuse must be replaced to correct this condition.

Over voltage indicates that the supply has exceeded the over voltage trip reference. This condition causes the supply to shutdown and optional SCR crowbar to fire. To clear this condition, the user must press the display/reset switch on the front panel. Upon pressing this switch, the over voltage trip and over current trip references are displayed and the over voltage condition is cleared. To restart the supply, simply press the start switch.

Over current indicates that the supply has exceeded the over current trip reference. To clear this condition, the user must press the display/reset switch on the front panel. Upon pressing this switch, the over voltage trip and over current trip references are displayed and the over current condition is cleared. To restart the supply, simply press the start switch.

The power supply requires closure of an interlock switch to be functional. One interlock switch is provided as switch position 3 of S1. As described earlier, the default position is 1, which

enables operation of the power supply. For external interlock operation, set switch position 3 of S1 to 0 and connect an external switch between terminals 14 and 10 of JS1.

Any diagnostic condition causes an alarm condition. This feature can be used as a standalone signal to indicate there is a problem.

Internal and external controls are programmed by switch positions 5 and 4 of S1, respectively. Internal control enables front panel start, stop, and reset switches and external control enables input digital lines; terminals 9, 22, and 23 of JS1.

2.11 Parallel Operation

Two or more PQ Series power supplies can be connected in parallel to obtain a total output current greater than that available from one power supply. The total output current is the sum of the output currents of the individual power supplies. Each power supply can be turned on or off separately.

WARNING: PQ series power supplies should not be connected in parallel with optional SCR crowbar. Operation of the crowbar in such a configuration can damage the power supply.

2.11.1 Parallel Operation - Direct

The simplest parallel connection involves attaching the positive terminals of all supplies to be paralleled to the positive point of the load and the negative terminals to the negative point of the load. The output current controls of each power supply can be separately set. The output voltage control of one power supply (master) should be set to the desired output voltage; the other power supply (slave) should be set for a slightly higher output voltage. The master will act as a constant voltage source; the slave will act as a constant current source, dropping its output voltage to equal that of the master.

2.11.2 Parallel Operation - Master/Slave

Master/slave parallel operation permits equal current sharing under all load conditions and allows complete control of output current from one master power supply.

Figure 2.7 illustrates the terminal connection for master/slave operation and salient control circuitry. Slave operation requires setting switch positions 3 and 4 of S2 to 0 and connecting a jumper between terminal 2 of JO2 to terminal 19 of JO2. To interface the slave to the master, connect terminal 16 of JO2 slave to terminal 1 of JO2 master and connect terminal 3 of JO2 slave to terminal 14 of JO2 master.

The auxiliary differential amplifier in the slave connects to the current sensing terminals of the master. This amplifier creates a current reference signal equal to that being sensed by the master. In master/slave parallel operation, the slave output voltage should be set slightly higher than that of the master.

To add a second slave, make the same connections to the current sensing terminals of the master and connect the second slave in parallel with the other two supplies.

2.12 Series Operation

Two or more power supplies can be connected in series to obtain a total output voltage greater than that available from one power supply. The total output voltage is the sum of the output voltage of the individual power supplies. Each power supply can be turned on or off separately.

WARNING: No plus or minus voltage should exceed 800 V with respect to ground.

2.12.1 Series Operation - Direct

The simplest series connection involves attaching the positive terminal of the first supply to the negative terminal of the second supply. The load is connected between the negative terminal of the first supply and the positive terminal of the second supply. The output current controls of each power supply are operative and the current limit is equal to the lowest control setting. If any one output current control is set too low with respect to the total output current, the series power supplies will automatically crossover to constant current operation and the output voltage will drop.

2.12.2 Series Operation - Master/Slave

Master/slave series operation permits equal voltage sharing under all load conditions and allows complete control of output voltage from one master power supply.

Figure 2.8 illustrates the terminal connection for master/slave operation and salient control circuitry. Slave operation requires setting switch positions 1 and 2 of S2 to 0 and connecting a jumper between terminal 15 of JO2 to terminal 7 of JO2. To interface the slave to the master, connect terminal 4 of JS2 slave to the positive output terminal of the master and connect terminal 3 of JS2 slave to the negative output terminal of the master. To minimize noise, wires between the master and slave should be #20 AWG twisted pair.

The auxiliary differential amplifier in the slave connects to the output of the master. This amplifier creates a voltage reference signal equal to that being sensed by the master. Master/slave series operation is intended only for power supplies with the same output voltage and current ratings.

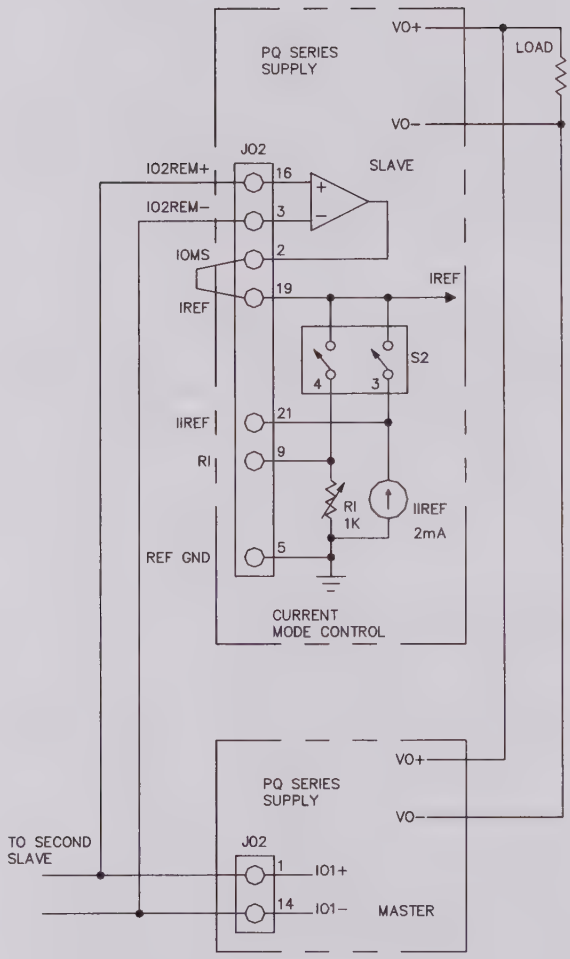


Figure 2.7 Master/slave parallel connection

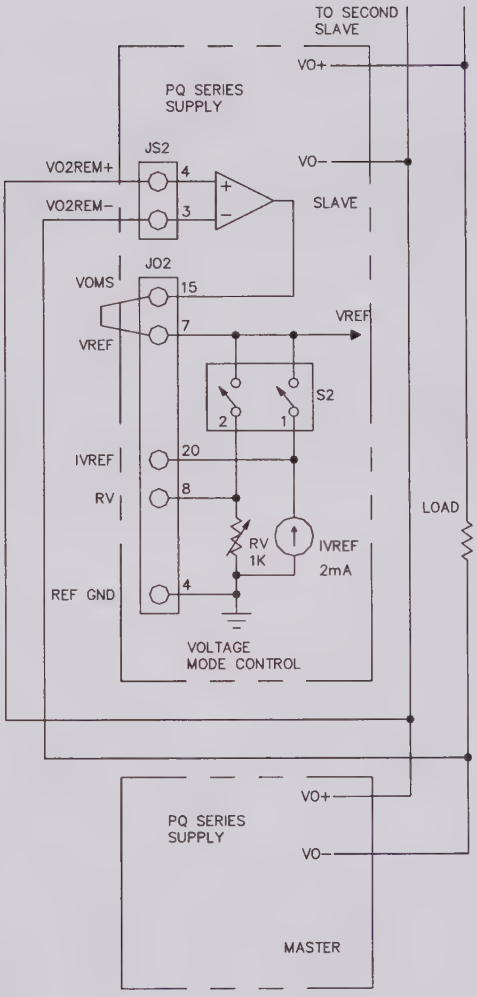


Figure 2.8 Master/slave series connection

To add a second slave, sense the output voltage of the first slave and place the second slave at the highest potential above ground. Do not sense the output voltage of the master, for this will damage the second slave.

2.13 Pulse Loading

The power supply will automatically crossover from constant voltage to constant current operation, or the reverse, in response to an increase (over the preset limit) in the output current or voltage, respectively. With preset limit set to the average output current or voltage, high peak currents or voltages, as occur in pulse loading, may exceed the preset limit conditions and cause crossover to occur. To avoid this unwanted crossover, the preset limit must be set for the peak requirement and not the average.

There are internal capacitors across the output terminals of the power supply. These capacitors help to supply high-current pulses of short duration during constant voltage operation. Any capacitance added externally will improve the pulse current capability, but will decrease the safety provided by the constant current circuit. A high-current pulse may damage load components before the average output current is large enough to cause the constant current circuit to operate.

2.14 Conversion to 240/440 V Operation

PQ series supplies are normally wired for 208 V, 3• •operation. For conversion to 240 V, 3• • operation, two connections have to be changed inside the supply.

Disconnect all power leads to the power supply and remove the top cover. Locate main transformer T1. Move the wire on tap 3 to tap 4 and move the wire on tap 2 to tap 1. Make sure the connections are secure. Replace the top cover. The conversion is complete.

A 480 V, 3• ;PQ power supply can be converted to 440 V by following a similar but reverse process.

Disconnect all power leads to the supply and remove the top cover. Locate main transformer T1. Move the wire on tap 4 to tap 3 and move the wire on tap 1 to tap 2. Make sure the connections are secure. Replace the top cover. The conversion is complete

2.15 Nomenclature

The following defines user connections on the terminal strips and input/output power connections.

AC INPUT:

A: Phase A input.

B: Phase B input.

C: Phase C input.

GND: System ground.

DC OUTPUT:

VO+: Positive output.

VO- : Negative output.

PROGRAMMING INPUTS:

REF GND: Reference ground.

VO1+: Positive output sense.

VO1-: Negative output sense.

VS+: Non-inverting input to voltage sense amplifier.

VS- : Inverting input to voltage sense amplifier.

VO1REM+: Remote positive voltage sense.

VO1REM-: Remote negative voltage sense.

VO2REM+: Remote positive voltage sense of second supply.

VO2REM-: Remote negative voltage sense of second supply.

VOMS: Master/slave output of voltage sense amplifier.

IO2REM+: Remote positive current sense of second supply.

IO2REM-: Remote negative current sense of second supply.

IOMS: Master/slave output of current sense amplifier.

IVREF: Voltage control reference current.

IIREF: Current control reference current.

ITVREF: Over voltage trip reference current.

ITIREF: Over current trip reference current.

RV: Voltage control resistance.

RI: Current control resistance.

RTV: Over voltage trip control resistance.

RTI: Over current trip control resistance.

VREF: Voltage control input reference.

IREF: Current control input reference.

TVREF: Over voltage trip control input reference.

TIREF: Over current trip control input reference.

IO1+: Positive current sense.

IO1-: Negative current sense.

OPTICALLY ISOLATED CONTROL INPUTS:

ISOLATED RTN: Return path for all optically isolated inputs and outputs.

Stop: Remote stop.

Start: Remote start.

Reset: Remote reset.

Interlock Set: Interlock set.

OPTICALLY ISOLATED DIGITAL OUTPUTS:

Standby: Standby.

Power: Control circuit power.

Int Ctl: Internal control.

Ext Ctl: External control.

PGM Line: Program line shutdown.

Over Voltage: Over voltage trip shutdown.

Over Current: Over current trip shutdown.

Phase Loss: Phase loss shutdown.

Thermal: Thermal overload shutdown.

Fuse: Fuse cleared.

Volt Control: Voltage control.

Cur Control: Current control.

Alarm: Alarm condition.

3.0 PRINCIPLES OF OPERATION

3.1 General

Figure 3.1 illustrates the block diagram of the PQ series power supply.

Power is fed through ac fuses and is distributed to a control transformer, inrush limiter, and main 3• •contactor. The control transformer powers a switching power supply in the driver board. Power from the switching power supply is fed to the other printed circuit boards in the PQ unit. The inrush limiter is a step start device with is used to initially charge capacitors on the input dc bus and limit the inrush of current. The inrush limiter is initiated when the power supply is switched from a standby to power state. After the charge cycle, the main 3• •contactor is energized and power is allowed to flow to the load. The optional EMI filter filters common mode and differential mode noise emanating from the supply.

Output power is controlled through a polyphase chopper. For a 10 kW PQ supply, three choppers, phased 120••apart, provide a current source to the medium frequency link inverter. The 6.6 kW PQ uses two choppers, phased 180••apart, and the 3.3 kW supply uses only one chopper. The choppers are controlled with current mode, pulse width modulation (PWM). This modulation scheme provides a quick response for transients and filtering harmonics on the dc bus. As illustrated, chopper output current is monitored for balancing and for sensing overload current conditions. The polyphase chopper has been engineered to eliminate harmonic components minimizing currents circulating in the power supply.

The polyphase chopper produces a controlled dc bus which is connected to dc link inductors and current fed, IGBT medium frequency link inverter. The inverter, which operates at 420 Hz to 780 Hz, excites the main transformer at higher than normal line frequencies. This operation produces ohmic isolation between the input and output of the power supply using a transformer of dramatically reduced size.

The output of the main power transformer is converted to dc via rectifiers. Low voltage versions of the PQ Series power supply use midpoint diode configurations and higher voltage versions use bridge configurations.

The dc output voltage is filtered with a pie section filter. This, in combination with the dc link inductors, form a double stage inductive capacitive (LC) filter.

The gate driver board supports a synchronized modulation scheme which integrates power semiconductor switching of the switching power supply, polyphase chopper, and medium frequency link inverter.

The fuse/phase detector senses input line voltage on each phase and continuity of each fuse. Upon detection

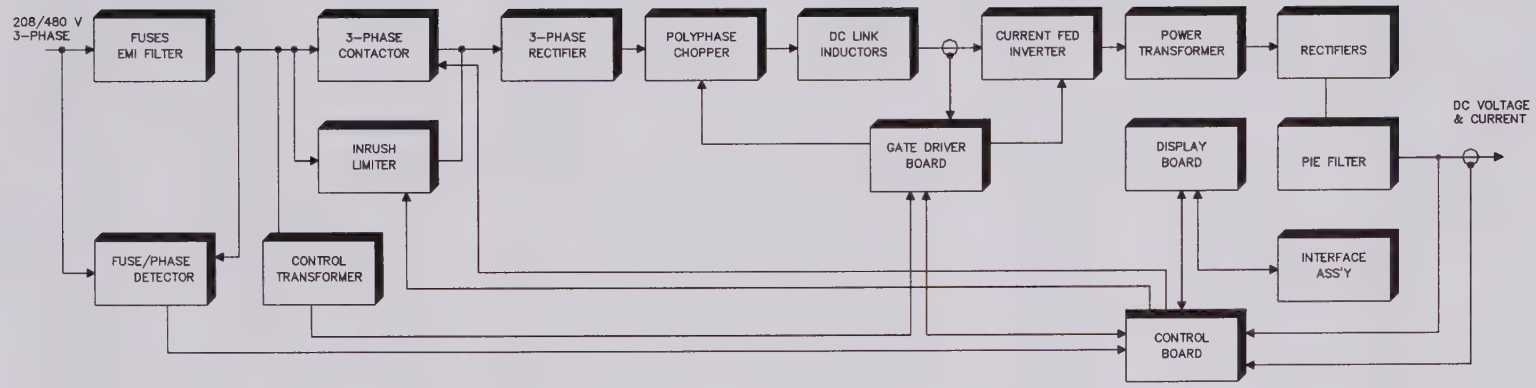


Figure 3.1 Block diagrams

of a problem, the control board is signaled to shutdown the system.

The display board contains light-emitting diodes for displaying diagnostic conditions and provides an interface for meters and switches. It also channels control and diagnostic functions to optical isolators for external functions.

All diagnostic functions are directly coupled to the error signal. This informs the user of precisely which function has control.

3.2 Theory of Operation

3.2.1 Power Circuit

Schematics* 108201, 108218, 108219, 108220 show the power circuit and connections to the printed circuit boards. Schematics* 108201 and 108218 illustrate 240 V input models and schematics* 108219 and 108220 illustrate 480 V input models.

Proceeding from left to right, the Input Board contains fuses, fuse/phase detector, and optional EMI filter. The Input Board connects to control transformer T2 and contactors K1 and K2. Contactor K2 and resistors R1 and R2 form the inrush limiter circuitry. When powered, contactor K2 charges the dc bus capacitors through diode bridge DB1. After approximately a second, contactor K1 is enabled allowing power to flow to the load. Control transformer T2 powers the Gate Driver board which contains a switching power supply.

Fans 1 and 2 are strategically arranged in the power supply to cool critical components.

The polyphase Chopper Module converts the incoming dc voltage to a controlled dc current. The Chopper Module uses current mode, pulse width modulation (PWM) to share current equally between the stages. Three stages are used for 10 kW models, two stages for 6.6 kW models, and one stage for 3.3 kW modules. Inductor L1 is used to increase the conduction period of the diode bridge DB1 to improve input power factor.

Inductors L3, L4, and L5 interface between the polyphase Chopper Module and the current fed Inverter Module. The Inverter Module contains four insulated gate bipolar transistors (IGBT's) which drive transformer T1 with a 420 to 780 Hz current square wave.

The secondary side of transformer T1 is connected in either a diode midpoint connection, schematics* 108201 and 108219, or a diode bridge configuration, schematics* 108218 and 108220. The rectified output voltage is fed to the Output Module which contains a pie filter and optional SCR crowbar circuitry.

The Gate Driver Board feeds the Chopper Module and Inverter Module with the proper gating signals. The Control Board sends control signals to the Gate Driver Board, receives output voltage and current signals from the Output Board, and accepts desired setpoint signals from the Display

Board. The Interface Board contains programming switches and interface external connectors for custom user connections.

Thermal switches TB1 and TB2 are connected to the two main heatsinks where the the main power semiconductors are mounted.

3.2.2 Input Board

Schematic* 108208 illustrates the Input Board. The Input Board contains system fuses, optional EMI filter, fuse detector, and 3• •ac voltage detector.

Fuses F1 through F3 feed power to the ac contactors and fuses F4 and F5 feed power to the control circuits. The fuse detector circuit, resistor R1 through R6, senses the status of fuses F1 through F3 and the phase detector, resistors R7 through R15 and diodes D1 through D3, senses the magnitude of phase to phase power mains voltage. Both the fuse detector and phase detector, which are connected to optical isolators, U1 through U4, interface to the control circuit.

3.2.3 Chopper Module

The Chopper Module is illustrated in schematics* 108205 and 108216, the circuits for 240 V and 480 V models, respectively.

As previously described, the Chopper Module consists of three sections that are phase 120••apart for 10 kW models, two sections that are phased 180••apart for 6.6 kW models, and one section for 3.3 kW models. The Chopper Module contains current transducers for detecting currents in each section.

IGBT's Q1 through Q3 are driven through driver amplifiers 108961 using current mode, pulse width modulation (PWM). During the on state, the insulated gate bipolar transistors (IGBT's) are conducting and during the off state diodes D1 through D3 are conducting. Depending on the PWM signal, the input voltage bus is reduced to a lower voltage and the output current is precisely controlled.

3.2.4 Inverter Module

The Inverter Module is illustrated in schematics* 108206 and 108217, the circuits for 240 V and 480 V models, respectively.

IGBT's Q1 through Q4 are inversely driven using driver amplifiers 108961 to produce a square wave at terminals N3 and N4. Resistors R1 through R4 and capacitors C1 through C4 limit dv/dt across the IGBT's which reduces voltage transients and improves electromagnetic interference (EMI).

3.2.5 Output Module

The Output Module is illustrated in schematics* 108207 and 108215, the circuits for low and high output voltage models, respectively.

The Output Module filters the rectified output voltage of the main transformer. Ac components consist of the commutation notches produced during switching of the Inverter Module and ripple current produced by the Chopper Module. The inductive input to the Inverter Module and the pie section filter of the Output Module form a double stage LC filter. The first capacitor section of the Output Module consists of capacitors C1, C2, C3, and C8. The second capacitor section consists of capacitors C4 and C9. Capacitors are connected in a parallel configuration for low voltage outputs, schematic* 108207, and a series parallel configuration for high voltage outputs, schematic* 108215. Capacitors C6 and C7 provide output common mode voltage suppression.

The optional SCR crowbar consists of SCR1 and inductor L1.

3.2.6 Other Printed Circuit Boards

The remaining printed circuit boards consist of the Gate Driver Board, 108945; the Control Board, 108944; Display Board, 108846; and Interface Board, 108947. These boards are strictly small signal and should be treated as replaceable subassemblies.

* Schematic will be provided by AMREL upon signing Non Disclosure agreement

4.0 MAINTENANCE AND TROUBLE SHOOTING

4.1 General

The PQ Series power supplies consist of a multistage power processing system. Because of its complexity, it is highly recommended that all repairs be performed by the factory or qualified power supply technician. Before attempting maintenance or repair, the technician should be familiar with the components of the systems and the theory of operation. Some basic test equipment is also necessary: source of ac power, means of loading the power supply, dc voltmeter with accuracy and resolution better than the unit specifications, and an oscilloscope. The chart in section 4.2 should aid in finding operational problems.

WARNING: When servicing the power supply, dangerous voltage levels exist. All ac and dc capacitors should be discharged. Be especially careful of person and equipment when measuring primary circuitry since this is at line potential.

4.2 Trouble Shooting Guide

1. Fuse F1, F2, or F3 blows when the power supply is turned on. Power supply has a short on the primary side.
   a. Check diode bridge DB1.
   b. Check for failed power semiconductor on the Chopper Module.
   c. Check for isolation to ground on the input side of the power supply.

2. Over current trips and power supply cannot be reset. An auxiliary over current detector limits input dc link current. Exceeding safe levels will cause an over current diagnostic condition that cannot be reset.
   a. Restart the supply. Transient voltages on the input voltage could have caused the problem.
   b. Check diodes D1 through D4 on the secondary side of transformer T1.
   c. Check for a shorted winding on transformer T1.
   d. Check for failed IGBT's in the Inverter Module.

3. Unit goes to high output immediately after starting.
   a. For local sensing, check that positions 1 and 2 of S1 are set to 1. For remote sensing, check that there is continuity of feedback signals on terminals 1 and 2 of JS2.
   b. Check for loose connectors internal to the power supply.

3. High ripple voltage.
   a. Check the mains voltage for balance and magnitude.

4.3 Calibration

4.3.1 Control Board

Current Reference Calibration

Set the power supply for remote resistive programming (see figures 2.4 and 2.5) using two external, precision 1K resistors. Set positions 2 and 4 of switch S2 to 0 and connect 1K precision, external resistors between terminals 20 and 4 of JO2 and terminals 21 and 5 of JO2.

First adjust potentiometer P6 for a 2.00 V drop across the external resistor at terminal 21 of JO2. Then adjust potentiometer P5 for a 2.00 V drop across the external resistor at terminal 20 of JO2.

Remove the external resistors and set positions 2 and 4 of S2 back to 1.

Voltage Amplifiers and Voltmeter Calibration

Connect jumpers on the rear of the power supply to monitor output voltage as illustrated in figure 2.6. This requires a jumper between the positive output terminal to terminal 4 of JS2 and a jumper between the negative output terminal to terminal 3 of JS2. Place the first dc voltmeter across output terminals of the power supply and place the second dc voltmeter across test point TP3 (positive) and test point TP4 (negative). Using voltage mode control, increase the output voltage using the front panel control until TP3 is 1.00 V. Adjust potentiometer P8 until the voltage output is set to half rating.

Place the second dc voltmeter across terminal 15 of JO2 and terminal 4 of JO2. Using voltage mode control, increase the output voltage to half rating and adjust potentiometer P1 to 1.00 V.

Using voltage mode control, increase the output voltage to half rating and adjust potentiometer P7 until the voltmeter of supply equals that of the first voltmeter.

Place the second dc voltmeter across terminal 6 of JO2 and terminal 4 of JO2. Using the over voltage trip potentiometer on the front panel, set the second dc voltmeter to 1.00 V. Pressing the display/reset switch on the front panel, adjust potentiometer P12 until the voltage reading is half rating.

Current Amplifiers and Ammeter Calibration

Place the reference dc ammeter, equal to the rating of the supply, across the output terminals of the supply. Connect jumpers on the rear of the power supply to monitor output current as illustrated in figure 2.6. This require a jumper between terminal 16 of JO2 to terminal 1 of JO2 and a jumper between terminal 3 of JO2 to terminal 14 of JO2. Place a dc voltmeter across test point TP1 (positive) and test point TP4 (negative). With power applied to the control circuit and with the main contactor off, adjust potentiometer P2 for a null at TP1. Using current mode control, increase the output current using the front panel control until TP1 is 1.00 V. Adjust potentiometer P9 until the current output is set to half rating.

Place the dc voltmeter across terminal 2 of JO2 and terminal 4 of JO2. With power applied to the control circuit and with the main contactor off, adjust potentiometer P3 for a null at terminal 2 of JO2. Using current mode control, increase the output current to half rating and adjust potentiometer P4 to 1.00 V.

Using current mode control, increase the output current to half rating and adjust potentiometer P10 until the ammeter of supply equals that of the output.

Place the dc voltmeter across terminal 18 of JO2 and terminal 5 of JO2. Using the over current trip potentiometer on the front panel, set the dc voltmeter to 1.00 V. Pressing the display/reset switch on the front panel, adjust potentiometer P11 until the current reading is half rating.

4.3.2 Driver Board

Over Current Trip

Over current trip should only be calibrated after consultation with the factory. *Gross misadjustment can cause inverter failure.*

Place the first dc voltmeter across test point TP5 and test point TP7. Place the second dc meter across test point TP6 and test point TP7. Apply full load to the power supply and monitor the voltage at test point TP5 when operating the power supply at nominal input voltage. Set test point TP6 to 130% of test point TP5 using potentiometer P1.

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